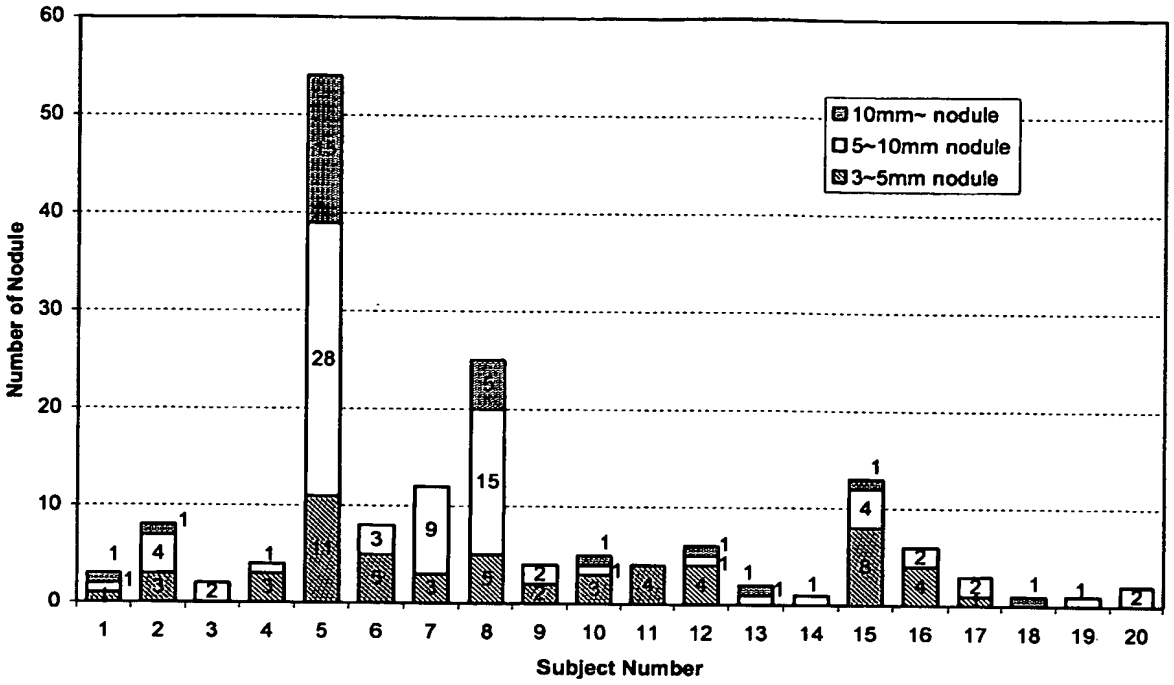

Figure 1. Bar graph showing the number and size distribution of lung nodules in 20 subjects. A total of 164 nodules were identified. Eighteen of 20 patients had 1-13 pulmonary nodules (mean 4.7), and the other 2 patients had 25 or 54 nodules in their CT.

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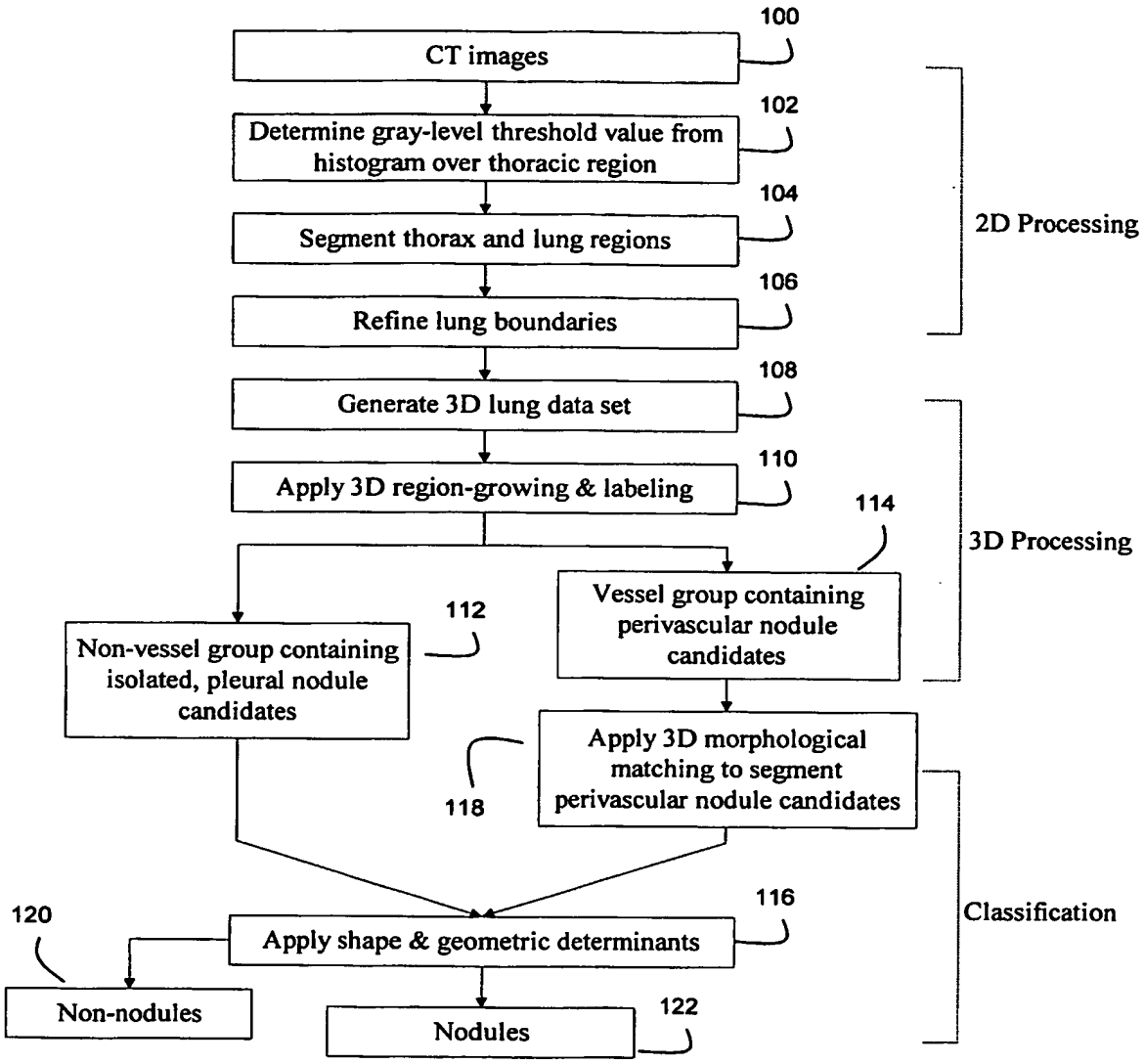


Figure 2. Flow diagram illustrating overall method for the automated lung nodule detection from CT images.

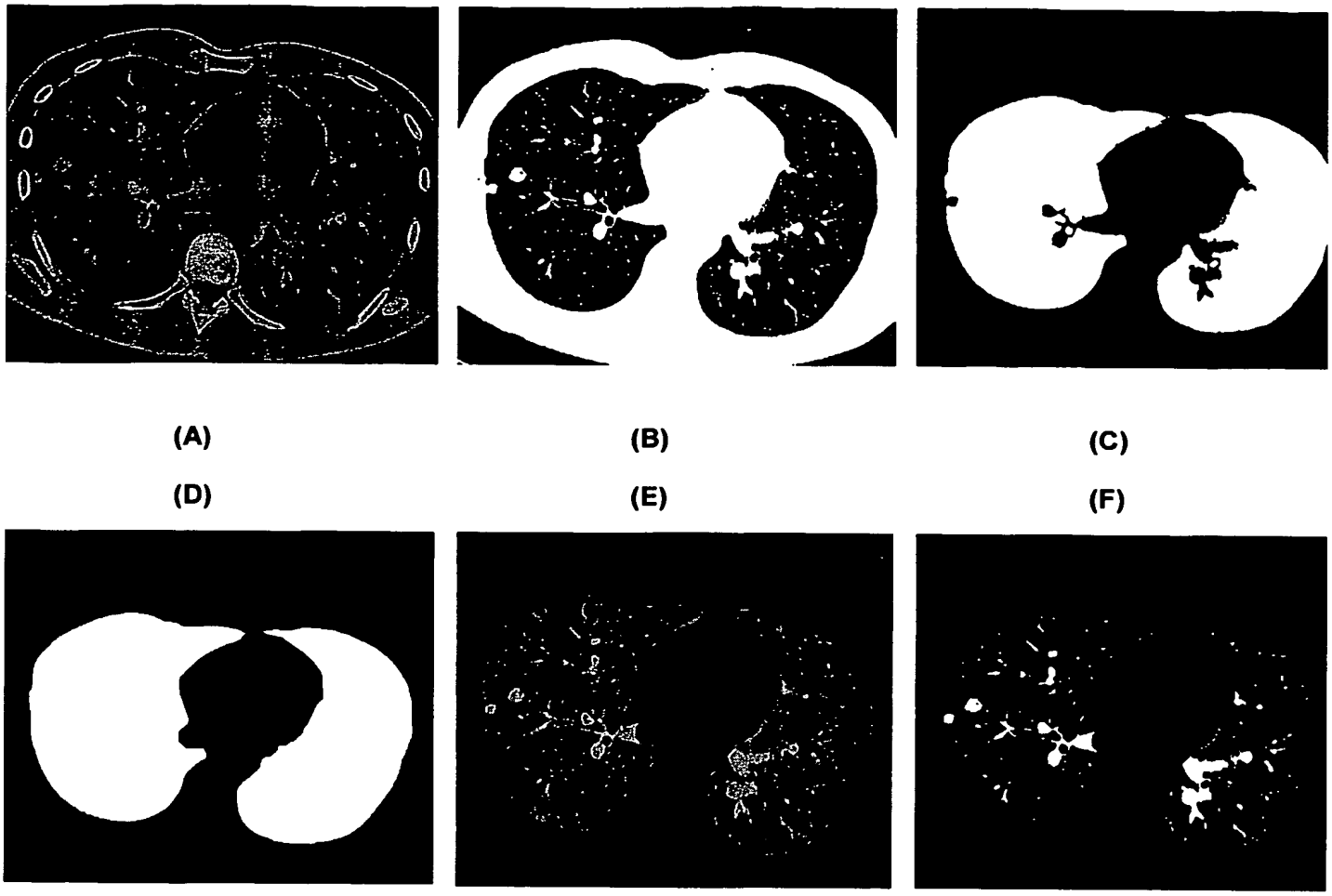
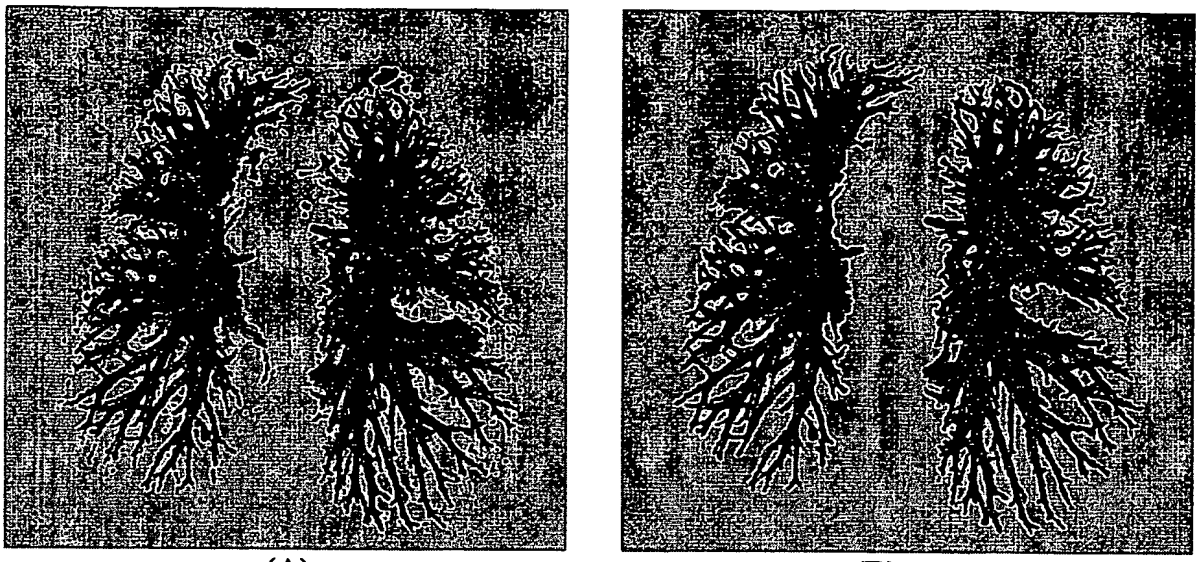


Figure 3. 2D intermediate CT images illustrating the lung region segmentation process. A transaxial CT image of the thorax from Subject 5 (Figure A) was gray-level thresholded to generate a binary image (Figure B). Initial uncorrected lung region (Figure C) was estimated. After a corrected lung boundary (Figure D) was determined, the initial CT image enclosed by this boundary was isolated (Figure E). The soft-tissue structures within the lung region were segmented by gray-level thresholding (Figure D).



(A) (B)

Figure 4. Segmented 3D volumetric data from Subject 15 (A) before and (B) after removing non-vessel group. Figure A was obtained by applying region-growing and labeling to a stack of 2D segmented lung images (a 2D image shown in Figure 2). This figure contains three types (isolated, pleural, and perivascular) of lung nodules, blood vessels, and noise voxels. The 3D data set in Figure B, i.e. the vessel group including perivascular nodules, represents a subset of the 3D data in Figure A after the structures not connected to the pulmonary vessels were removed.

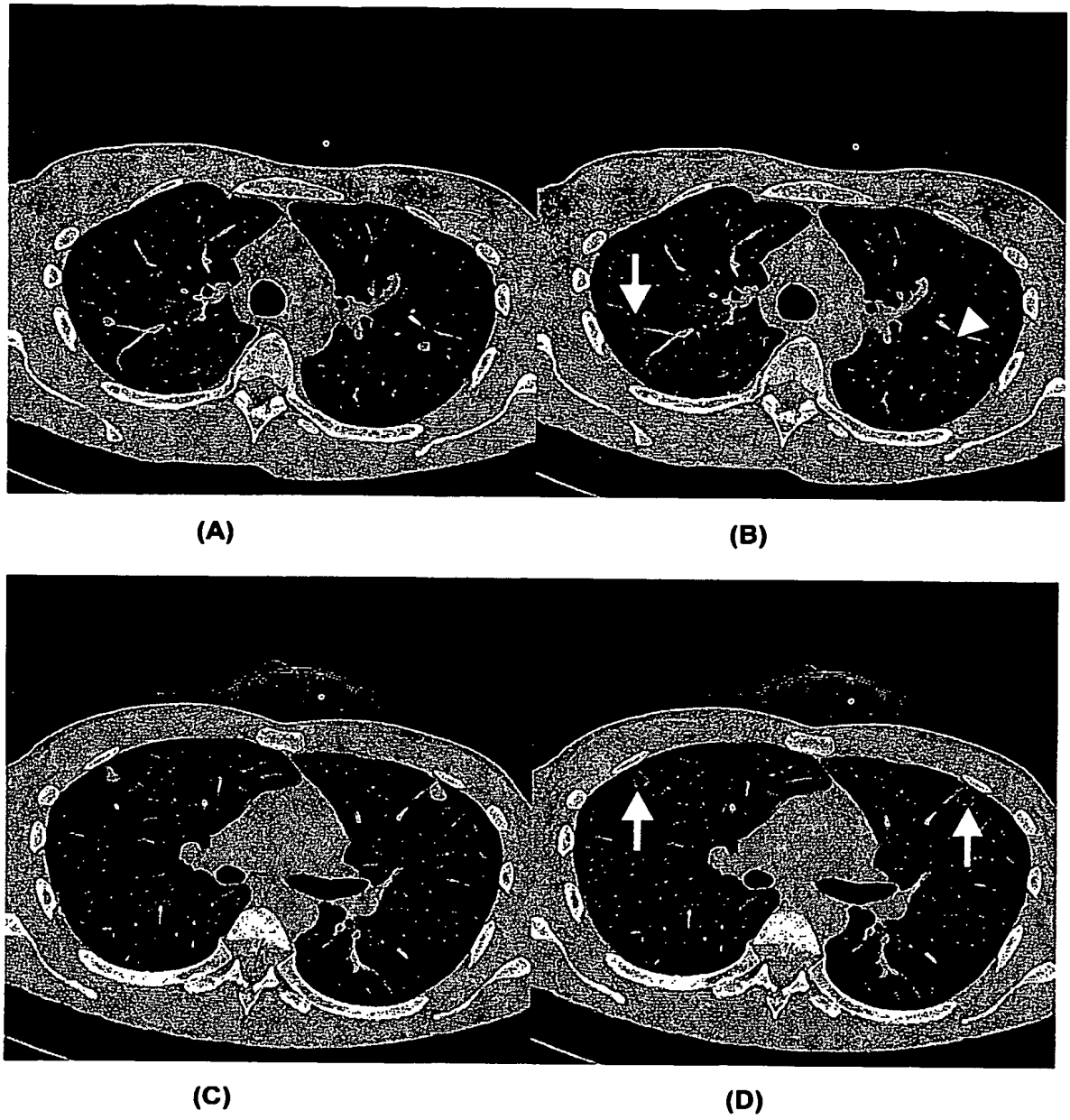
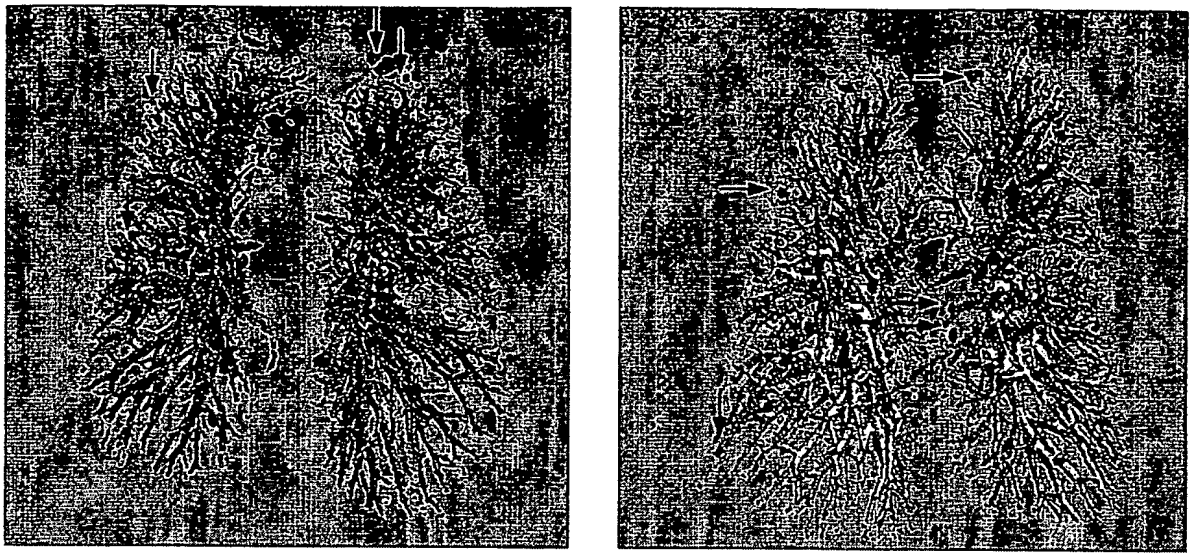


Figure 5. Transaxial CT images (A, C) with nodules detected by CAD (B, D) from Subject 5. Figure B shows perivascular (arrow) and isolated (arrow head) nodules detected from the CT image in Figure A. Figure D shows two pleural nodules (arrows) detected from the CT image in Figure C. No false negative or false positive nodules are observed in these two CT images.



(A) (B)

Figure 6. (A) anterior and (B) posterior views of 3D volumetric representation of pulmonary vessels and detected lung nodules (in red) from Subject 15. This subject had a total of 13 nodules (7 isolated, 3 pleural, and 3 perivascular nodules) and all of them were detected. Two false positives were identified.

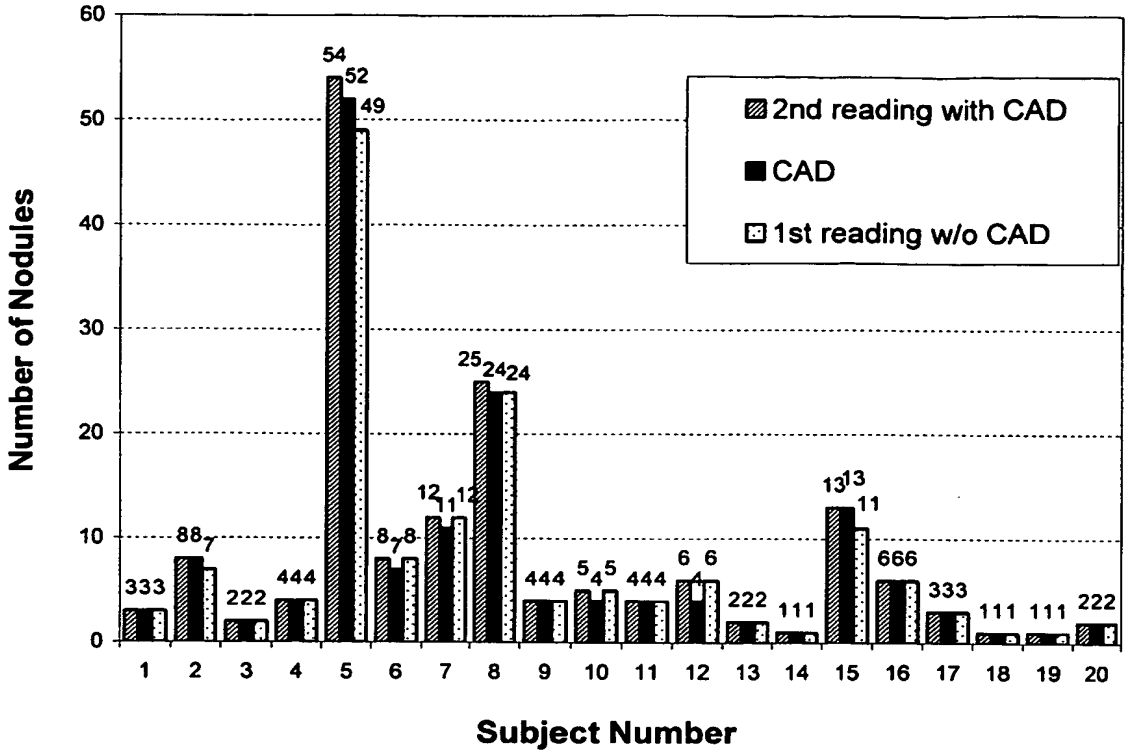


Figure 7. Bar graph showing the number of lung nodules detected by CAD and a chest radiologist (1st reading without CAD and 2nd reading with CAD) in 20 subjects. Lung nodule detection by CAD was highly accurate and better than the radiologist's 1st reading without CAD.

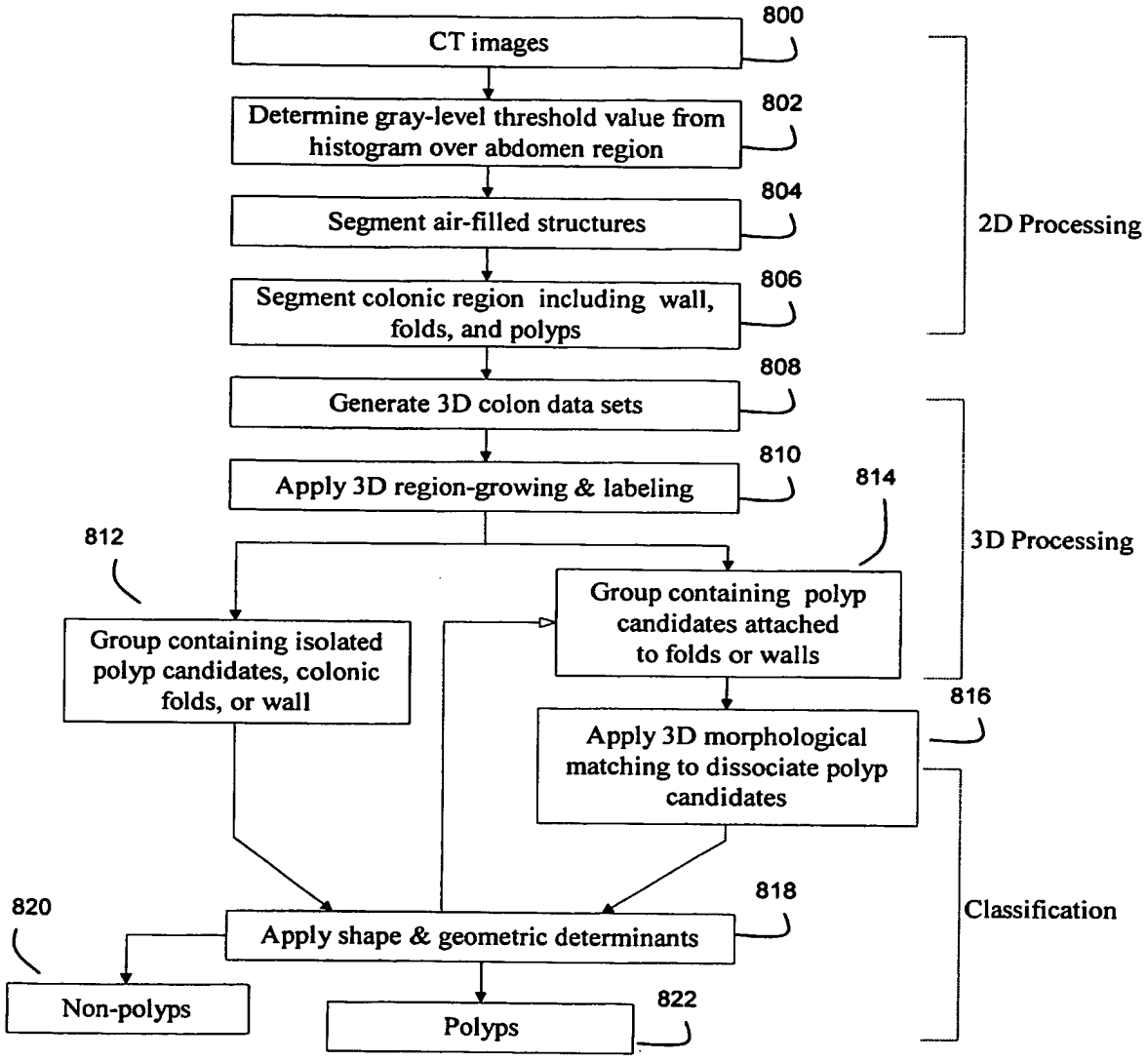

CT images
800
Determine gray-level threshold value from histogram over abdomen region
802
Segment air-filled structures
804
Segment colonic region including wall, folds, and polyps
806
2D Processing
Generate 3D colon data sets
808
Apply 3D region-growing & labeling
810
814
812
3D Processing
Group containing isolated polyp candidates, colonic folds, or wall
Group containing polyp candidates attached to folds or walls
816
Apply 3D morphological matching to dissociate polyp candidates
820
818
Apply shape & geometric determinants
Classification
Non-polyps
822
Polyps

Figure 8

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